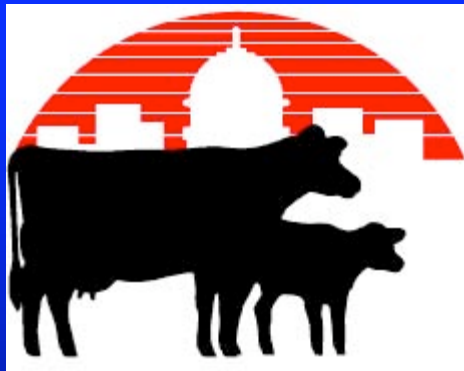# Research Associate

## Department of Dairy Science

## UW Madison

## (2000-2003)

# Estimating nitrogen loss from dairy cow manure
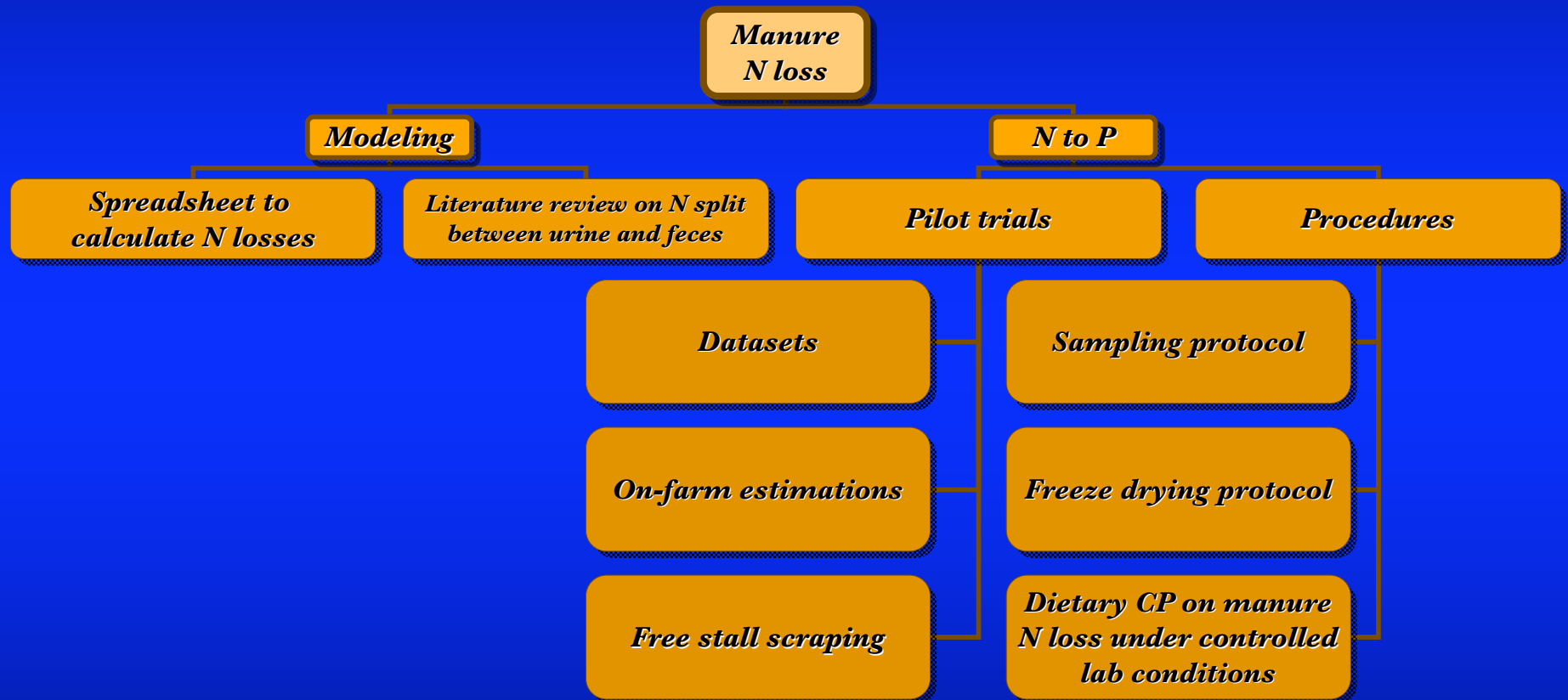
**Vinicius R. Moreira**

**and Larry D. Satter**

**Department of Dairy Science / UW-Madison**

**USDA-ARS DFRC**

04/09/03

# Synopsis of activities

```
                        Manure
                        N loss
            ┌──────────────┴──────────────────┐
        Modeling                            N to P
      ┌─────┴─────┐                    ┌───────┴───────┐
Spreadsheet to   Literature review    Pilot trials    Procedures
calculate N      on N split
losses           between urine
                 and feces

                    Datasets         Sampling protocol

                    On-farm          Freeze drying
                    estimations      protocol

                    Free stall       Dietary CP on manure
                    scraping         N loss under controlled
                                     lab conditions
```

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# Modeling N losses

- **Assumptions for the dairy cow:**
  - 13-month calving interval: 310d lactation + 55d dry in a year, producing one calf;
  - Primiparous accounted for ~1/3 of the herd (some N retention);
  - Rolling-herd average: 9100kg milk with 3.2%CP;
  - Dry matter intake: 23.2kg/d while lactating and 12.5kg/d for the dry period;
  - Dietary CP: 17.5% and 13.5% for lactating and dry period diets, respectively
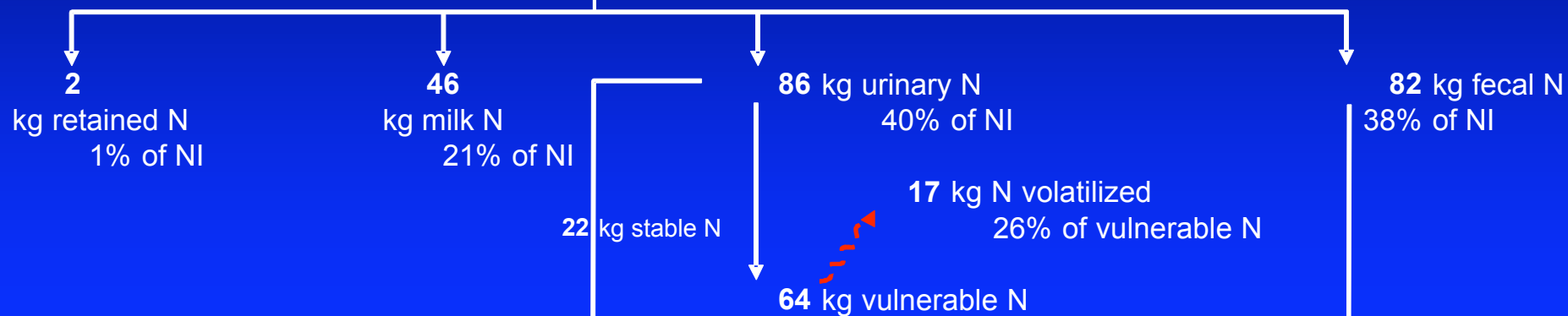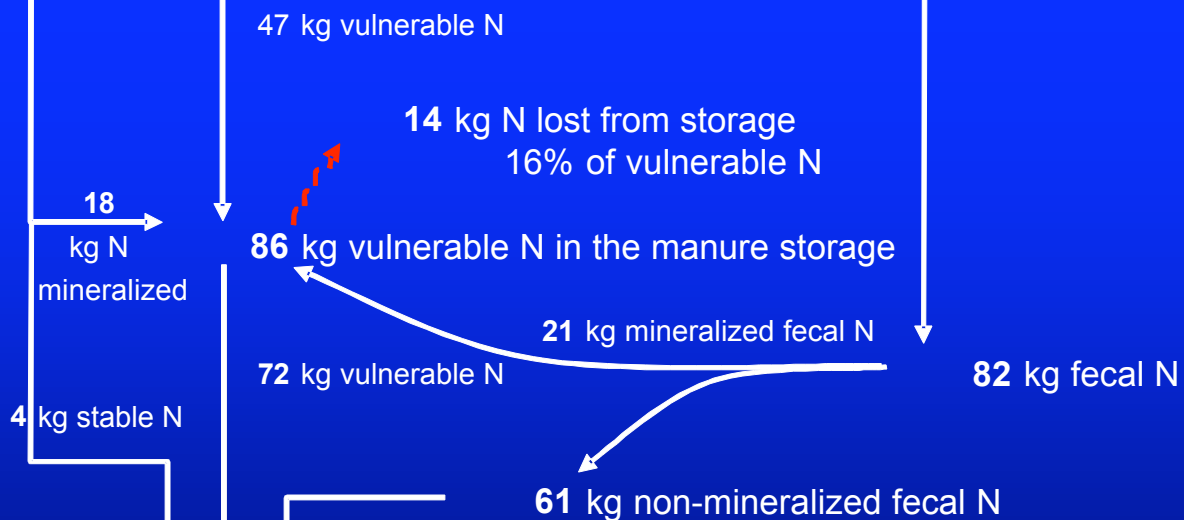
# Conventions

N retained

N lost

**BARN**
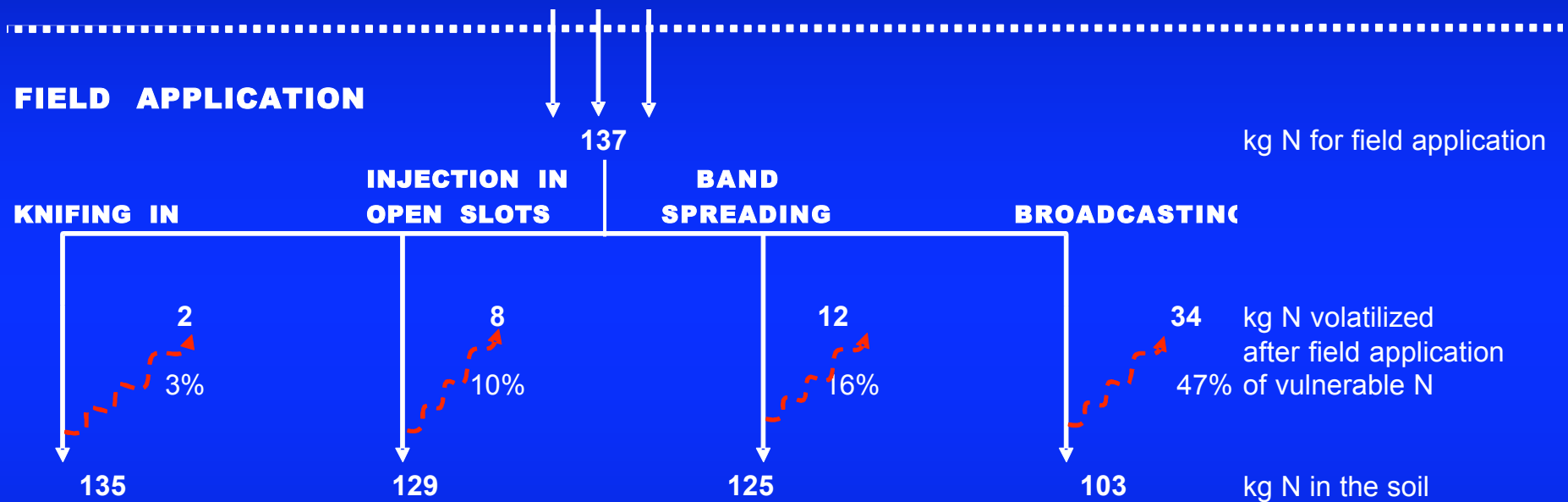
**DAIRY COW**

**216** kg nitrogen intake / cow / 365d

**2**
kg retained N
1% of NI

**46**
kg milk N
21% of NI

**86** kg urinary N
40% of NI

**82** kg fecal N
38% of NI

**22** kg stable N

**17** kg N volatilized
26% of vulnerable N

**64** kg vulnerable N

**STORAGE**

47 kg vulnerable N

**14** kg N lost from storage
16% of vulnerable N

**18**
kg N
mineralized

**86** kg vulnerable N in the manure storage

21 kg mineralized fecal N

72 kg vulnerable N

**82** kg fecal N

**4** kg stable N

**61** kg non-mineralized fecal N

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**Moreira and Satter, 2003**

**FIELD APPLICATION**

**137**                                                                    kg N for field application

|  | **INJECTION IN**<br>**OPEN SLOTS** | **BAND**<br>**SPREADING** |  |
|---|---|---|---|
| **KNIFING IN** |  |  | **BROADCASTING** |

**2**                    **8**                    **12**                    **34**    kg N volatilized
                                                                                    after field application
3%                 10%                 16%              47%    of vulnerable N

**135**              **129**              **125**              **103**    kg N in the soil

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**Moreira and Satter, 2003**

# Research

# Estimating N loss from dairy manure using N to P ratio

04/09/03

# General objective

- To evaluate the impact of dairy manure management on N loss from the moment of excretion until the manure storage facility is emptied, using N to P ratio.

# N and P flow thru a lactating dairy cow



By difference:
336gN & 47gP
N/P = 7.15
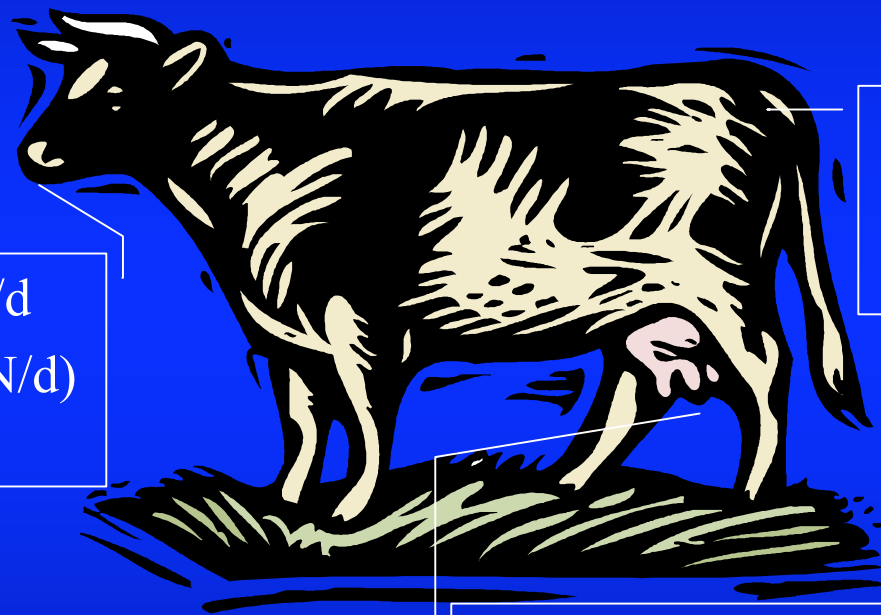
DMI = 17.6kg/d
16.8%CP (473gN/d)
0.42%P (72gP/d)

Milk = 27.8kg/d
3.13%CP (137gN/d)
0.09%P (25gP/d)

# Sources for N and P loss from dairy production systems



↥N

↥N

↥N

↥N

↥N & P

↥N

↧N & P

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# N and P flow

N and P intake

(-) (-)

N and P in milk    N and P retained

(=)

N:P in manure

N volatilized    (-)

(=)

Manure N:P after storage
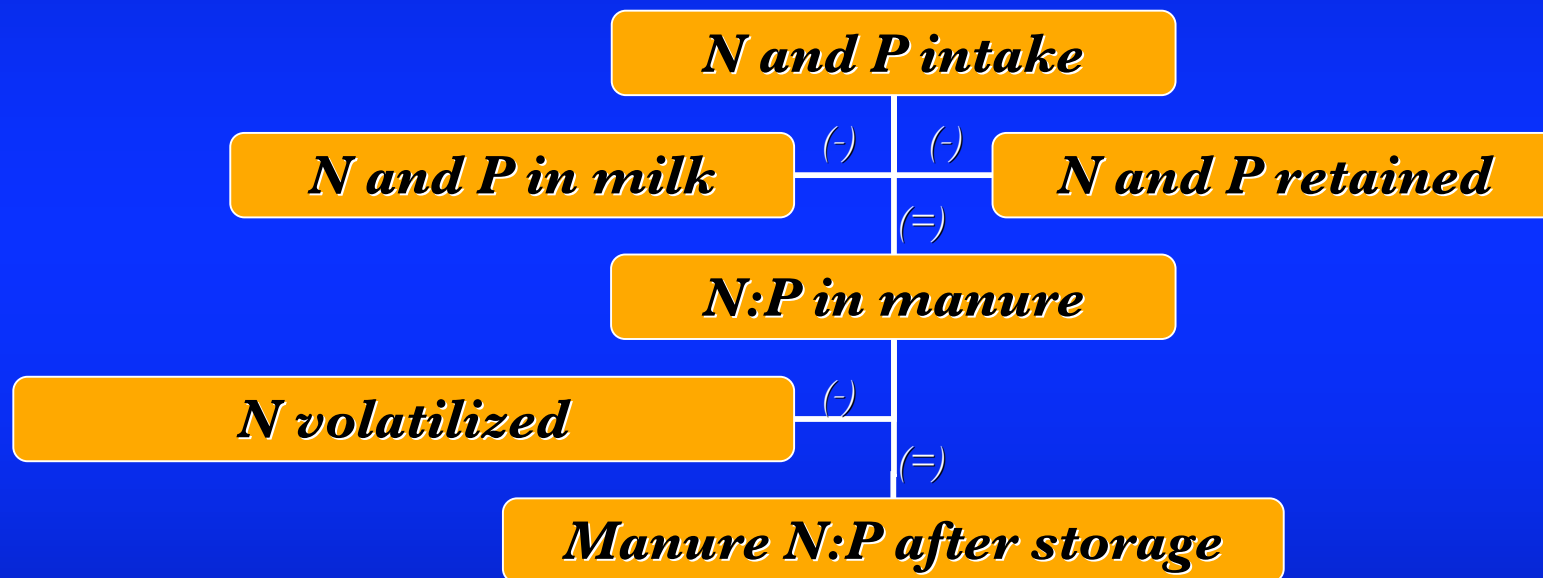
# Data-set analysis

- 1496 analyses from:
    - Minnesota;
    - Pennsylvania;
    - Wisconsin.

# Data-set analysis

- Characterization:
  - Manure management practice;
  - Liquid slurry storage loading method;
  - Liquid slurry storage coverage;
  - Type of cow bedding used;
  - Season.
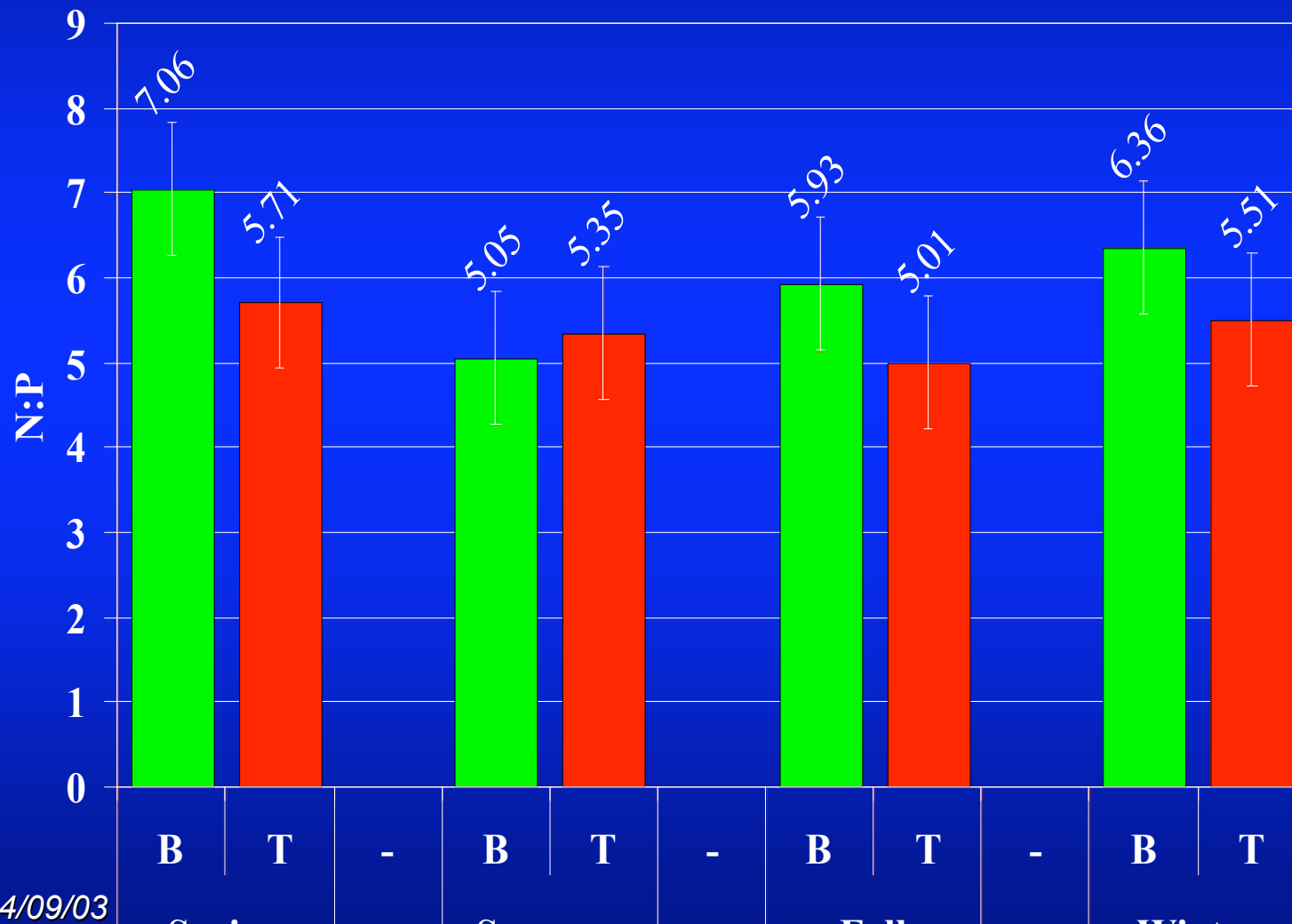
# Data-set – Storage management
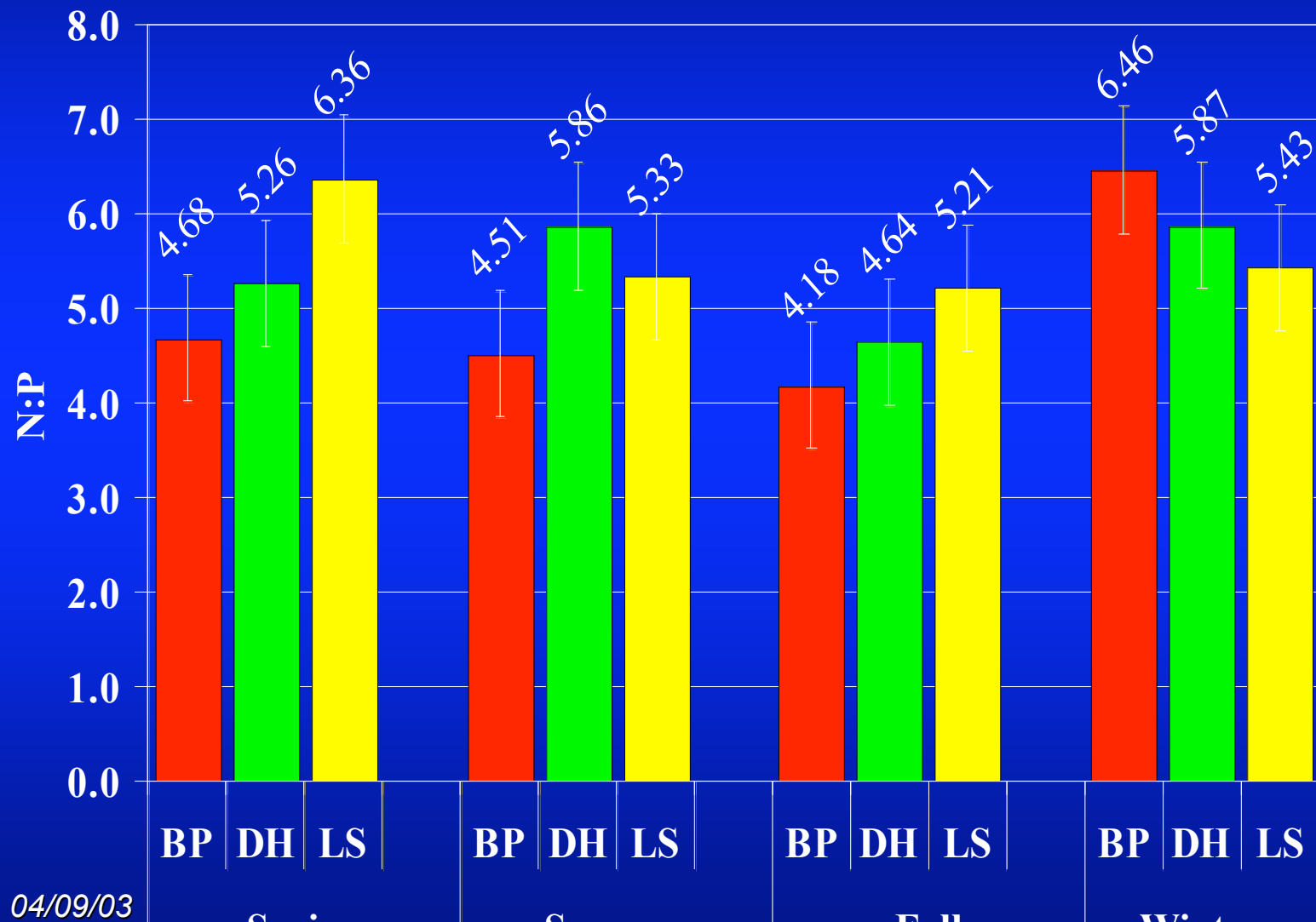


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# Data-set – Percent of N-NH$_3$ by manure storage management
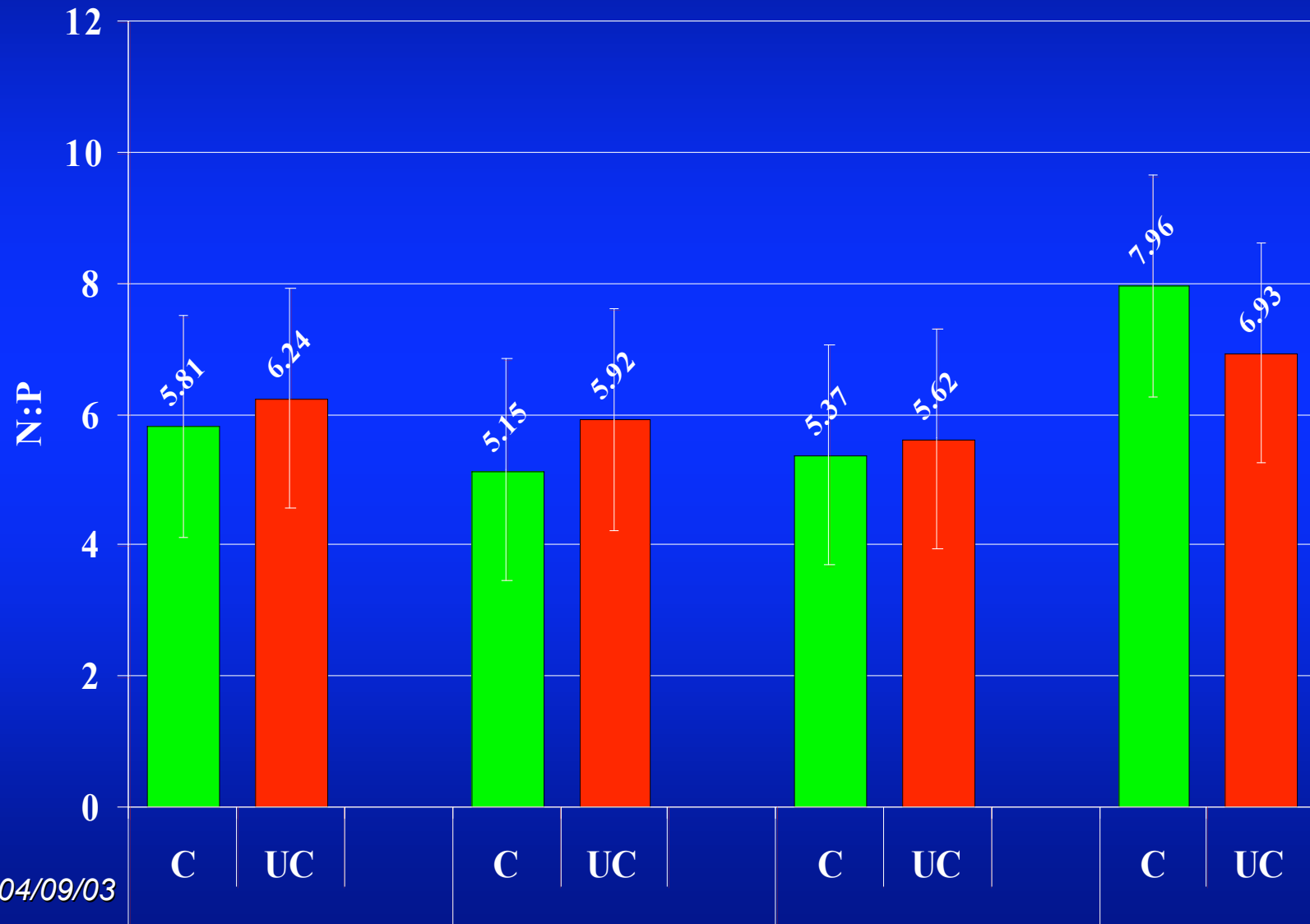


04/09/03

# Data-set – Storage loading method

# Data-set – Storage coverage



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# On-Farm Estimations

- Objective

  – To estimate N disappearance from dairy manure from excretion until storage is emptied using P as a marker (N to P ratio).

# On-Farm Estimations

- Materials and methods

  - 13 farms were selected;

  - Samples collected:

    - Manure samples: collected throughout emptying of storage facility;
    - Sampling period: March 27th through May 29th 2001

# On-Farm Estimations

- Materials and methods

    - Information:

        - Diet nutrient composition (CP and P)

        - Housing (type and management);

        - Milk records and diet composition (N and P);

        - Manure storage (type and management);

        - Hauling schedule.

# On-Farm Estimations

- Materials and methods

    – Sample processing was similar to that of Validation Protocol;

    – TN analyses were done in half of the sub-samples that were lyophilized.

# On-Farm Estimations

- Results

| | pH | T (°C) | DM (%) | TN (%DM) | Ash (%DM) | P (%DM) | N:P |
|---|---|---|---|---|---|---|---|
| Overall avg | 7.31 | 14.98 | 12.28 | 3.33 | 36.7 | 0.63 | 5.54 |
| Sand bedding | 7.40 | 15.6 | 15.2 | 2.79 | 51.2 | 0.47 | 5.91 |
| Sawdust bedding | 7.19 | 14.1 | 8.73 | 3.99 | 19.2 | 0.81 | 5.09 |
| Stdev | 0.48 | 5.30 | 4.38 | 0.82 | 17.4 | 0.21 | 0.82 |
| CV | 6.58 | 35.4 | 35.7 | 24.6 | 47.4 | 33.5 | 14.9 |
| Max | 8.52 | 23.7 | 19.8 | 4.34 | 58.3 | 0.92 | 6.49 |
| Min | 6.85 | 6.34 | 6.73 | 1.74 | 17.1 | 0.36 | 4.03 |

| FARM | 4 | 5 | 6 |
|---|---|---|---|
| **Nutrients intake (kg/cow/d)** | | | |
| TN | 0.742 | 0.707 | 0.730 |
| TP | 0.112 | 0.110 | 0.116 |
| **Nutrients secreted in milk (kg/cow/d)** | | | |
| Milk N | 0.168 | 0.177 | 0.208 |
| Milk P | 0.031 | 0.032 | 0.038 |
| **Nutrient excreted in manure (kg/cow/d):** | | | |
| TN (g) | 0.574 | 0.531 | 0.522 |
| TP (g) | 0.081 | 0.078 | 0.078 |
| N/P | 7.05 | 6.80 | 6.72 |
| | | | |
| **Manure Analyses** | | | |
| TN (%DM) | 2.881 | 4.337 | 3.649 |
| TP (%DM) | 0.521 | 0.814 | 0.586 |
| N/P | 5.39 | 5.51 | 6.45 |
| **% estimated N loss** | 23.5 | 19.0 | 4.0 |
| | | | |
| Scraping frequency | 2 | - | 2 |
| Bedding | Sand | Sawdust | Sand |
| Manure storage | Top loaded pit | Slatted floor w/ pit underneath barn | Top loaded pit |
| Storage period | 2-4wks | 6mo | 24h |

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# On-Farm Estimations of Nitrogen Losses Through Storage (% excreted N)
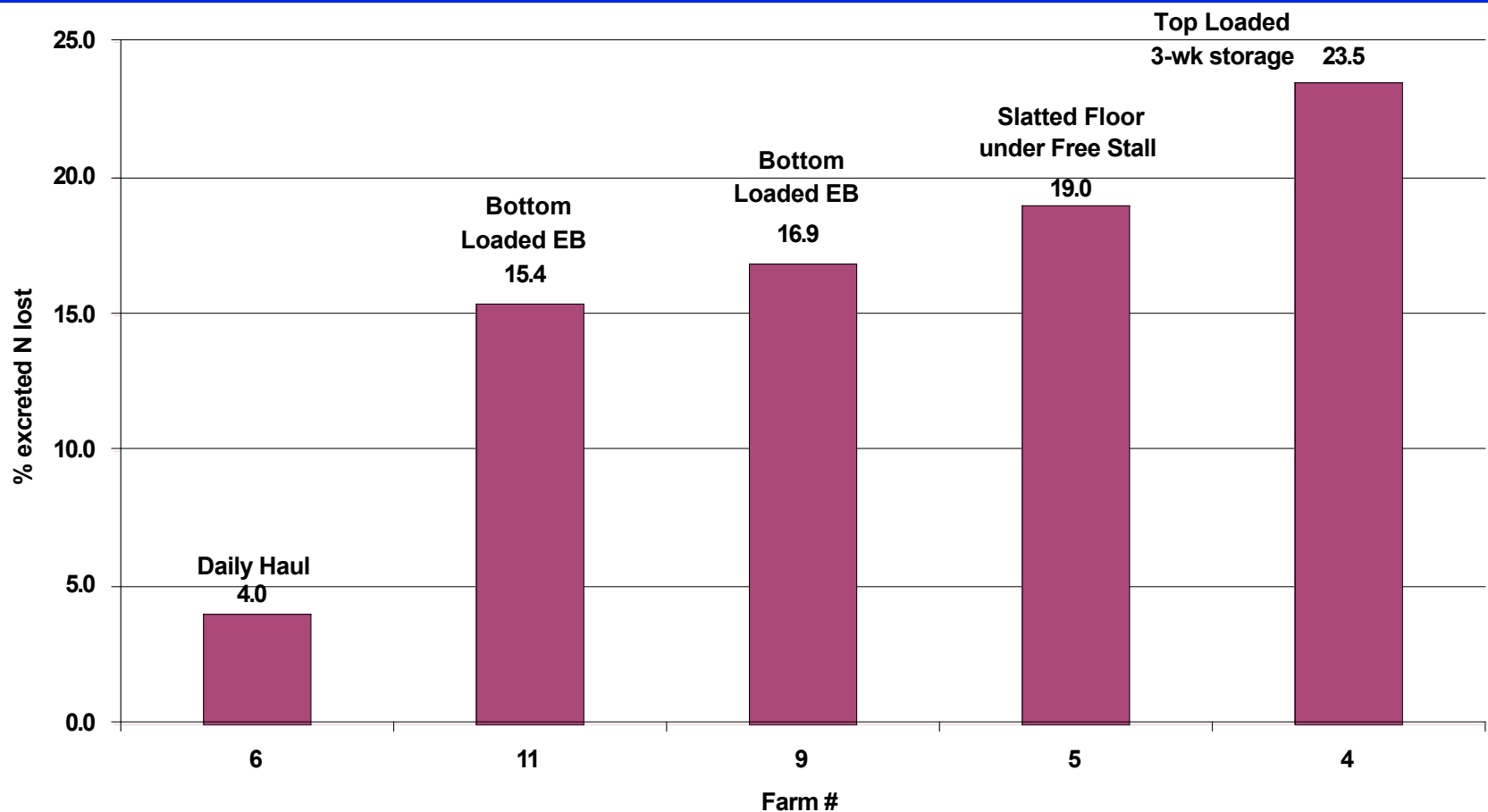


04/09/03

# Free stall – Pilot trial

Moreira, V. R., H. H. B. Santos, and L. D. Satter

- Objectives
  - To evaluate the use of N to P ratio for estimating N disappearance from manure;
  - To develop a methodology for sampling and processing manure from free-stall floor;
  - To determine N disappearance from free-stall.

# Free stall – Pilot trial
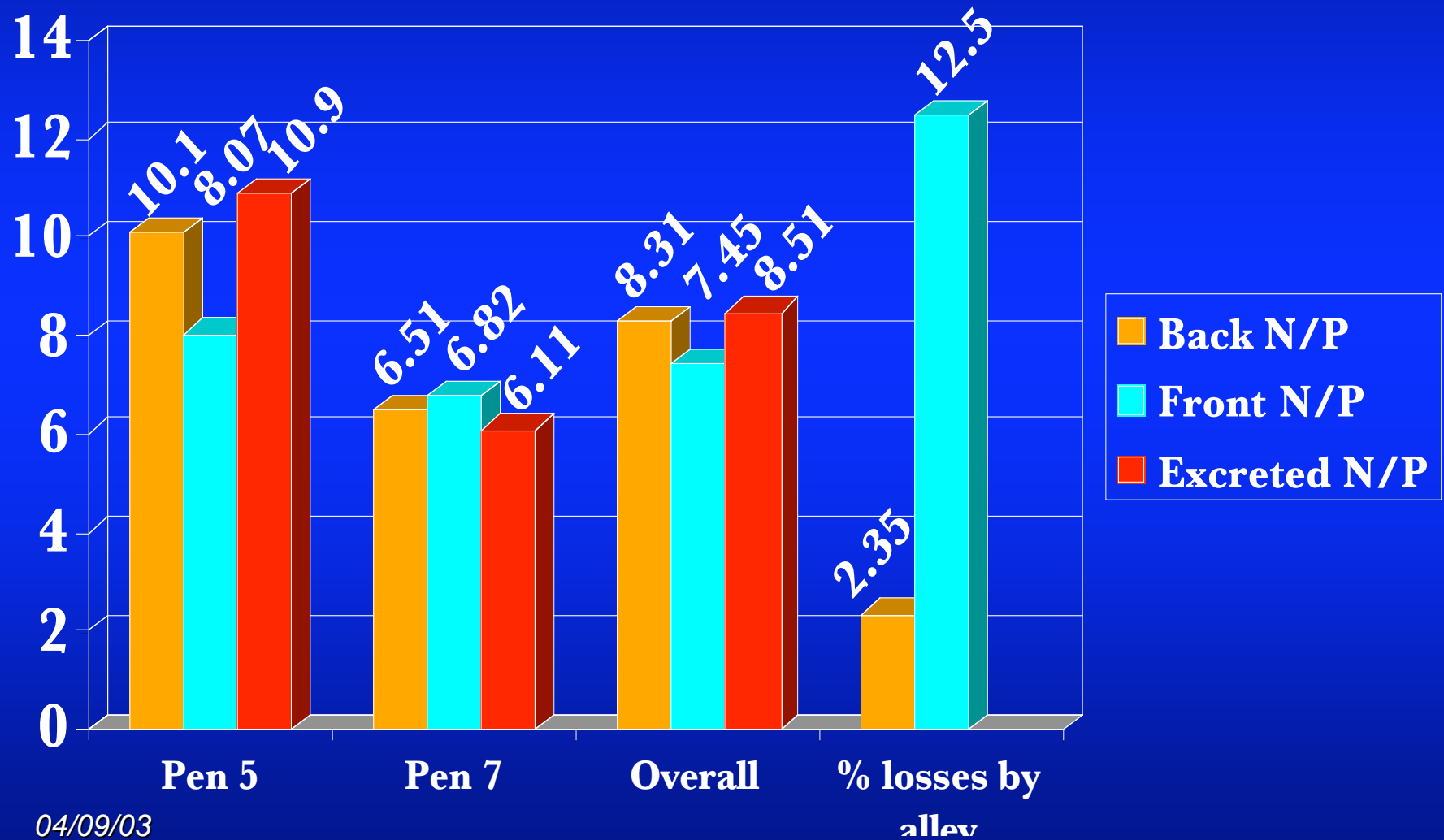
- Materials and methods

|  | Free-stall |
| --- | --- |
| Dates | Feb 9-10th 2001 |
| # Groups (pens) | 2 |
| # Cows | 96 early to mid-lactation dairy cows |
| Diets | 2 (P = .38 & .55%DM; same N=3.08%DM) |
| DMI | Estimated |
| MY | Individually (35 and 33.4kg/cow/d; CP=3.10%) |
| # scraping per day | 6-10 (run automatic and manually) |
| Sampling | 3x (7:00pm; 1:00am; 9:00am) |

# Free stall − Pilot trial

# Free stall – Pilot trial Conclusions

- Care should be exercised to minimize urine contamination between pens;

- It seems possible to estimate N loss from dairy manure in free-stall barn using N to P ratio;

- Due to different urine/feces ratio of excretion in front and back alleys, N loss can only be presented as a range.

- N loss appear to be low in winter (air T $<10^{o}$C).

N to P –
Scraping
Summer – 2001

04/09/03

# Hypothesis

- Scraping frequently will reduce N loss during Summer.

# Objective

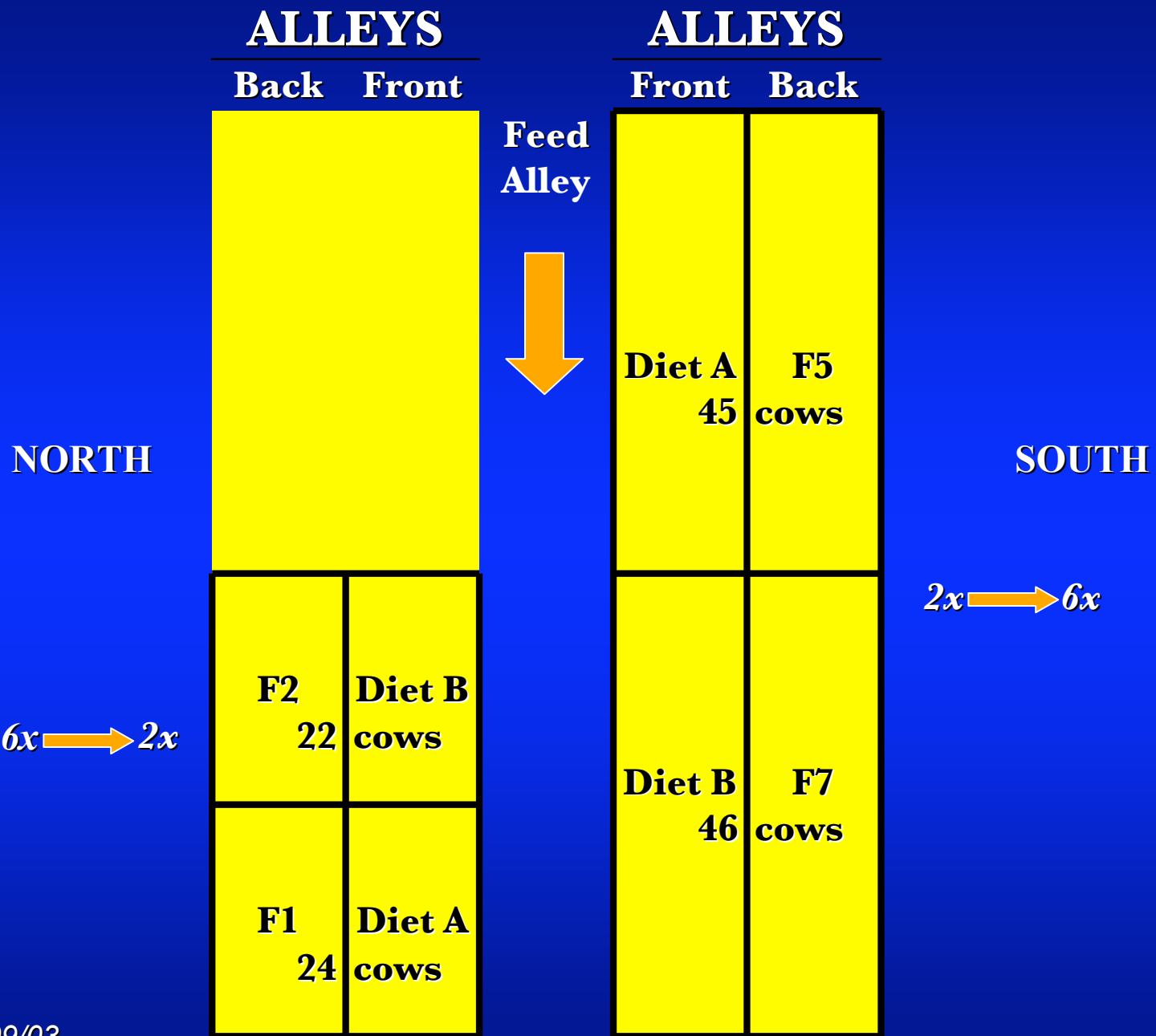- To evaluate the effect of scraping frequency on N disappearance, as estimated by N to P ratio.

*04/09/03*

# Materials and Methods

- <span style="color:red">Treatments:</span>
  - Floors were scraped 2 or 6-times a day;
  - Times (2 - 24h periods):
    - 2x: 8am and 7pm;
    - 6x: 9am, noon, 3pm, 6pm, 11pm, 4am.

- <span style="color:red">Design and schedule:</span>
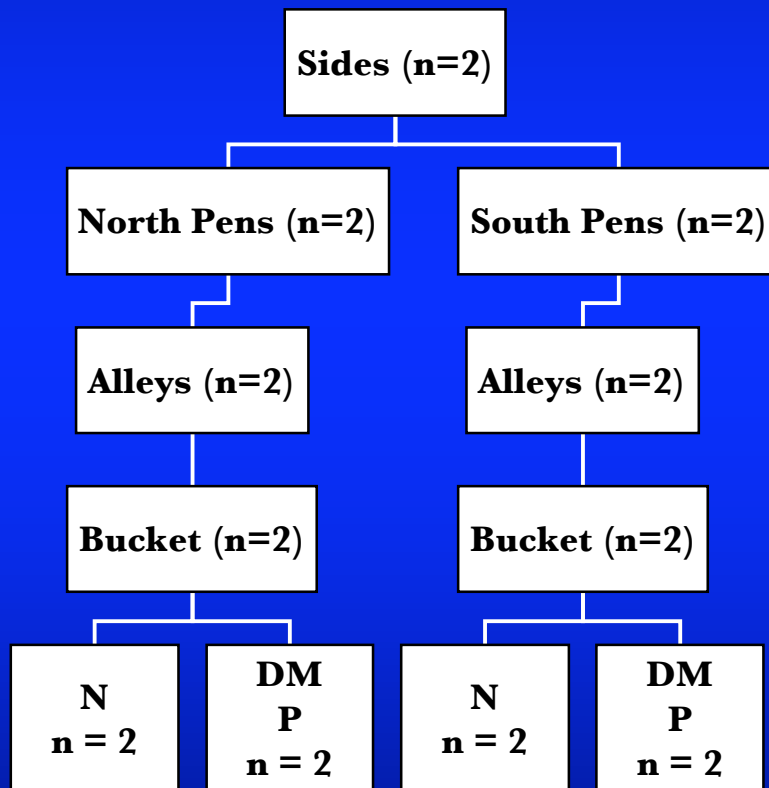  - Cross-over design;

*04/09/03*

# Materials and Methods

- Cows & diets:
  - 137 mid-lactation dairy cows;

  - Milk yield = 30-32kg/cow/d (3.20%CP);

  - Diet: P = .38 & .55%DM; same N = 3.08%DM;

  - DMI was calculated based on NRC (2001) model.

04/09/03

# Sampling Protocol

## Sampling Free-Stall

```
                    ┌──────────────────┐
                    │  Sides (n=2)     │
                    └──────────────────┘
              ┌───────────────┴───────────────┐
    ┌──────────────────┐          ┌──────────────────┐
    │ North Pens (n=2) │          │ South Pens (n=2) │
    └──────────────────┘          └──────────────────┘
              │                             │
    ┌──────────────────┐          ┌──────────────────┐
    │  Alleys (n=2)    │          │  Alleys (n=2)    │
    └──────────────────┘          └──────────────────┘
              │                             │
    ┌──────────────────┐          ┌──────────────────┐
    │  Bucket (n=2)    │          │  Bucket (n=2)    │
    └──────────────────┘          └──────────────────┘
        ┌─────┴─────┐                ┌─────┴─────┐
   ┌────────┐  ┌────────┐       ┌────────┐  ┌────────┐
   │   N    │  │  DM    │       │   N    │  │  DM    │
   │        │  │   P    │       │        │  │   P    │
   │ n = 2  │  │ n = 2  │       │ n = 2  │  │ n = 2  │
   └────────┘  └────────┘       └────────┘  └────────┘
```

- **Processing and analyses:**
  - For N:
    - Acidified ($67\%H_2SO_4$);
    - Frozen immediately;
    - Freeze-dried and ground 1mm screen.
    - Leco N analyzer.
  - For P:
    - DM analyses;
    - Ground 1mm screen;
    - DCP analyses.

# Results

| Manure analyses | Scraping frequency (Freq) | | | | SEM | Effects ($P\leq$) | | |
| | 2x | | 6x | | | Freq | alley | Day *Freq |
| | Front alley | Back alley | Front alley | Back alley | | | | |
|---|---|---|---|---|---|---|---|---|
| pH | 7.73 | 8.15 | 7.84 | 8.04 | 0.14 | 1.00 | 0.01 | 0.43 |
| Manure T, ºC | 21.7 | 23.2 | 22 | 22.3 | 0.52 | 0.48 | 0.29 | 0.23 |
| Dry matter, % | 10.7 | 11.6 | 11.4 | 11.9 | 0.48 | 0.26 | 0.01 | 0.71 |
| N, %DM | 4.09 | 4.04 | 3.86 | 3.86 | 0.1 | 0.03 | 0.75 | 0.32 |
| Ash, %DM | 16.5 | 17.9 | 16.1 | 16.7 | 0.51 | 0.11 | 0.01 | 0.05 |
| P, %DM | 0.95 | 0.93 | 0.96 | 0.95 | 0.04 | 0.67 | 0.54 | 0.05 |
| **N:P** | 4.44 | 4.62 | 4.16 | 4.19 | 0.17 | 0.03 | 0.36 | 0.04 |
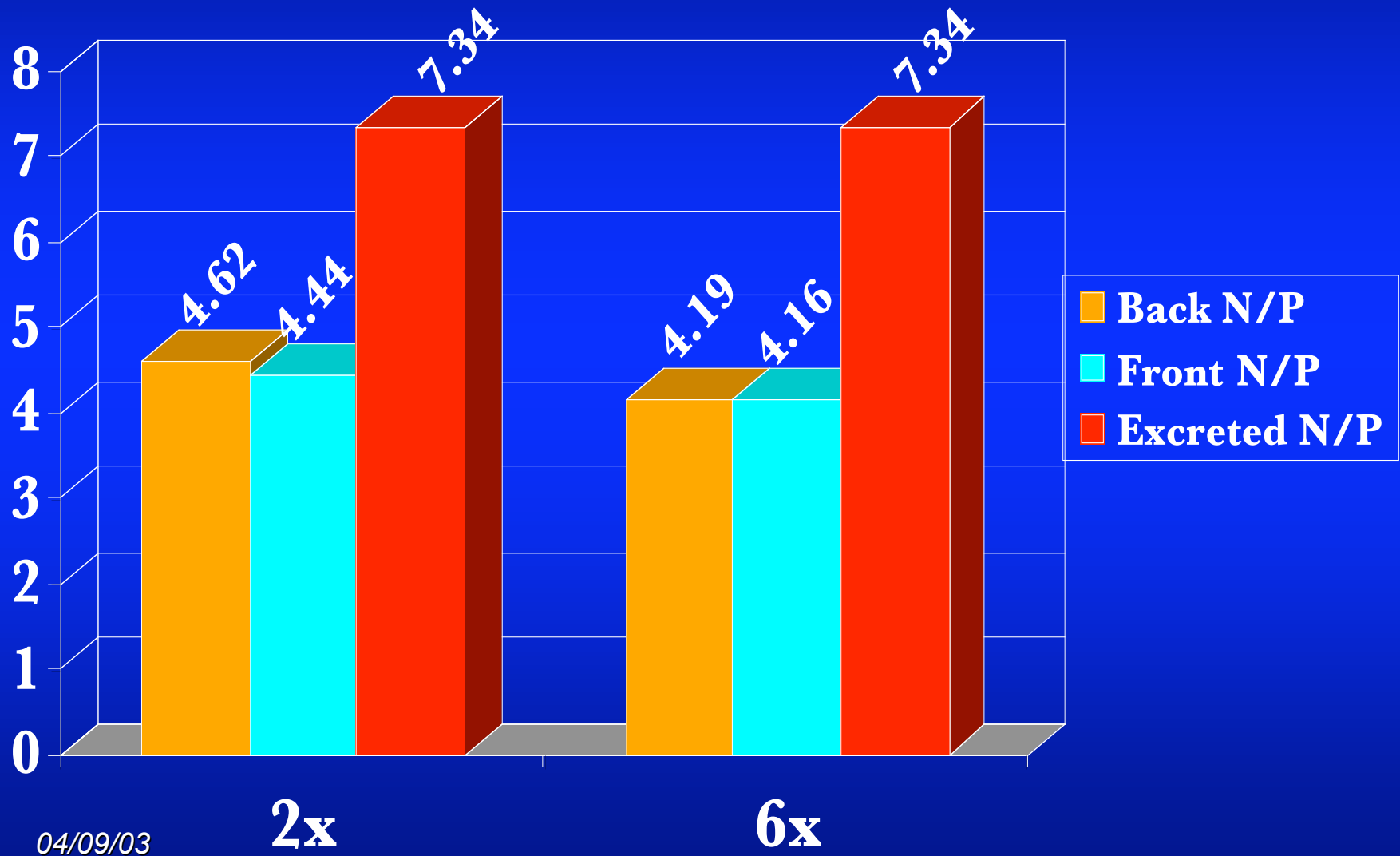
# Estimating N Loss
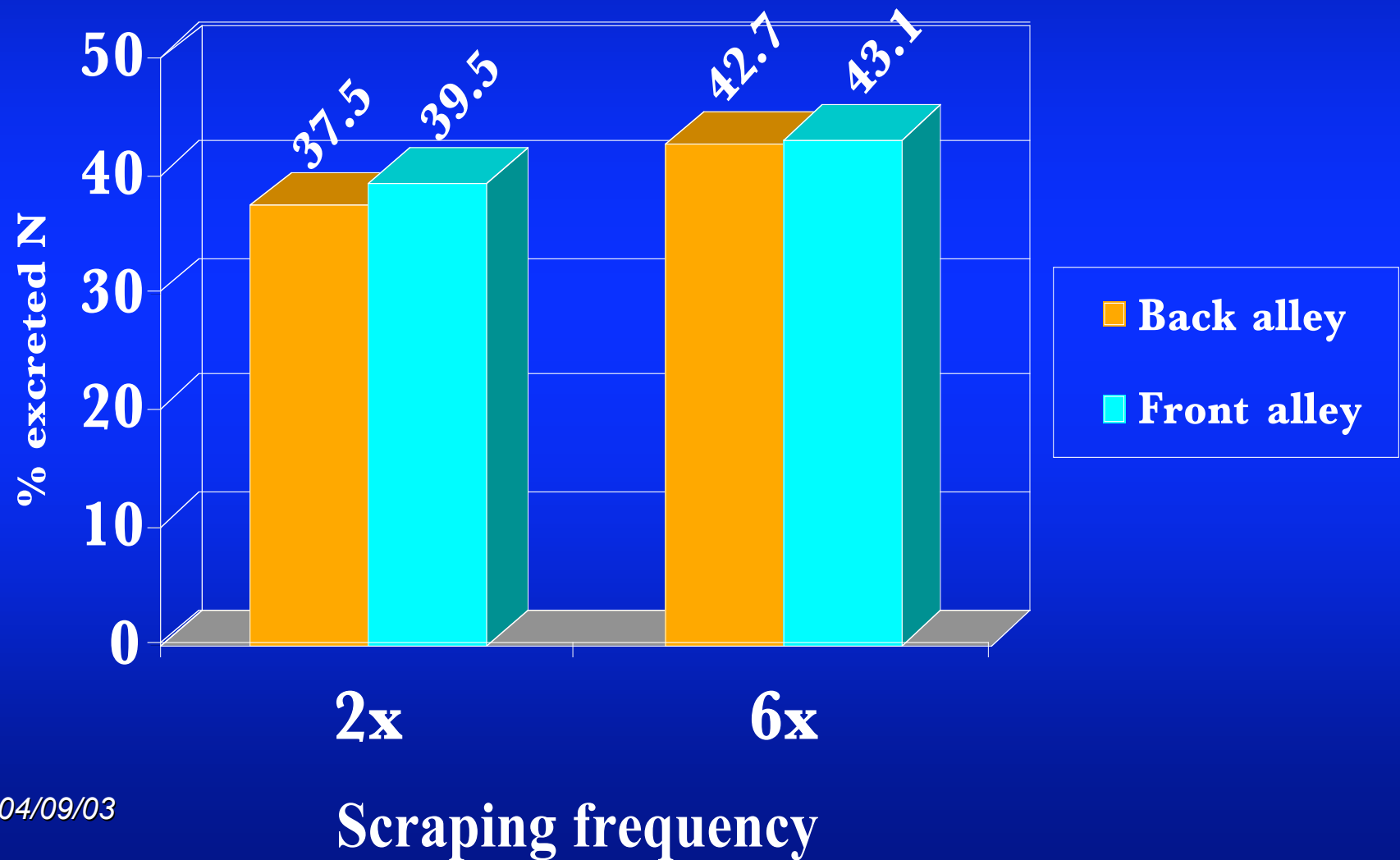


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# Conclusion

Increased scraping frequency does not seem to improve N retention in dairy manure under summer conditions;

# Publications and Presentations

- Lab Datasets: ADSA2002;

- Frequency of scraping: ADSA2003, Feedstuffs (Jul/03); Dairy Herd Management (Sep/03);

- On-farm: Discovery Conference (Apr/02);

- Model of N volatilization: Chapter on Ammonia Emissions from Confinement Dairy Operations.

*04/09/03*